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固体力学与飞行器总体设计

三维编织复合材料热物理性能的有限元分析

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Finite Element Analysis on Thermo-physical Properties of 3D Braided Composites

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摘要 根据三维编织复合材料的细观结构, 分别建立了三维四向和五向编织复合材料热物理性能的有限元模型。采用周期性的非绝热温度边界条件和位移边界条件,计算了三维四向和五向编织复合材料的整体等效热传导系数和热膨胀系数,计算结果同已有文献相比与实验值符合得更好。在此基础上,进一步研究了编织角、纤维体积分数、编织结构等参数对材料热物理性能的影响规律。结果表明,三维编织复合材料的热物理性能具有明显的各向异性,热膨胀性能随参数的变化规律相比热传导性能更具非线性特征。且所得结果与实验值符合较好,证实了本文模型的有效性,为材料热学问题和力热耦合问题的分析提供了有用参考。

关键词： 三维编织 热传导 热膨胀 有限元 单胞

Abstract： Based on the meso-structure of three-dimensional (3D) braided composites, the finite element models of thermo-physical properties of four-directional and five-directional composites are established. By using the periodic non-adiabatic temperature boundary condition and displacement boundary condition, the global effective thermal conductivity coefficient and thermal expansion coefficient are calculated, which are in a better agreement with experimental results than the previous literature. Based on this, the law of thermo-physical properties influenced by material parameters (i.e. braiding angle, fiber volume fraction and braiding structure) are also studied. The thermo-physical properties of 3D braided composites are significantly anisotropic, and the tendency of the thermal expansion properties with material parameters is more non-linear than the thermal conductivity properties.

Keywords： 3D braided composites thermal conductivity thermal expansion finite element method unit cell

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